Spatial Quantile Analysis of Real Estate Prices in Germany

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Abstract

The aim of the paper is to identify and establish empirical facts on the determinants of the real estate prices by analysing spatial regional data, considering the price level of the region. We provide empirical analysis on the panel data set of 401 German regions for the period 2004 – 2020 considering their relative geographical location and prices. The main contribution of our paper is the analysis of determinants and spatial effects in housing prices, considering whether the region belongs to high-prices or low-prices clusters using quantile regression analysis.

Introduction

It is a common knowledge that regions of one country can have different economic development levels. It is a long-time tendency for both developing and developed countries, but the type of polarization may differ. For instance, we know the historical differences of Western and Eastern Germany that somehow remains today, but not so much because of convergence process. Italy is characterized by the North-South polarization [Cascio, Bagarani, 2020]. In many other European countries and Russia there are some main agglomerations constructed from the closely located regions and centre-province polarization tendencies.

Although German regions are gaining a common economic development and price levels, clusterization still remains visible. Now we can highlight some main cities, such as Munich, Frankfurt, Stuttgart, Berlin and so on which unite their neighbouring regions by market prices and some other features such as demographical structure and demand and supply characteristics. Until the regions do not have the uniform economic development level, that is quite naive to expect in the near future, we can observe some economic processes independently to get

more precise results, as surely various macroeconomic determinants can provide different effects.

Mostly the economic disparities are driven by the historical events. After the WW2 the country was divided into occupation zones with different economic systems. For almost half of the century these two parts developed in opposite ways, that played significant role in future divergence. After the reunion the regions began to converge, but it is a long process, that can be complicated by demographic factors, migration and economic patterns. So nowadays regions are much closer to each other than they used to be, but do not have a uniform economic development level. Housing prices usually reflect the economic situation of the region, as more developed districts are usually expensive to live in, so they vary by the region greatly as well.

The main aim of this paper is to analyze regional housing prices taking into account the fact, that the regions have different economic environment and price level. We perform the analysis using quantile regression method. It means that the regions are divided to quantiles by their housing price level and then the results got from the analysis are more precise, as we get not a uniform correlation value, but differentiated result for each quantile.

The paper consists of theoretical analysis of market situation in Germany and the illustration of disparities across the regions. Then we provide a literature review to find out which gaps exist. Afterwards we build various spatial econometric models to estimate the correlation between socio-economic factors and prices for rent and selling in high- and low-priced regions.

Disparities of German Regions

Despite the fact that Germany nowadays is quite successful concerning divergence reducing policies, the economic situations in its regions remain different by many reasons. The historical premise of it is the division of the country in 20th century which is still noticeable due to different and even opposite economic, political and ideological background of several generations.

There are various factors which differ among the regions. Demographical situation is a key point affecting the economic development as it defines the demand. Usually, it is unemployment and poverty level, population density, affordability of education and housing, migration ratio, age structure, etc.

Income demographic factors affect the housing market directly. Poverty is a more common feature for Eastern regions rather than Western as its level of it is 5-7% higher there. [Suhr, 2017] The wages of women in Eastern regions are lower than in Western. Moreover, if we compare female and male wages in different regions, the results are frightening: in Western regions the share of women paid less is 23%, while in Eastern – 40%. The more is this percentage, the worse economic situation is. [Khrishkevich, 2018] The number of people receiving unemployment benefits by Hartz-IV is 5-15% higher in Eastern regions [Khrishkevich, 2016]. However, the minimum wage level is unified for all regions in 2015.

Population density is heterogenous in different regions. The most populous are Hanseatic cities and South-western regions. Berlin as a capital of the country has the greatest population density [Zensus, 2011a]. The low density can show a prospect for future building expansion of the territory. On the other hand, it is evidence of low demand and unattractiveness of the region for migrants. Although it illustrates weakness of Eastern economies, the rate of employable population there is higher than overall for Germany with the highest in Berlin, Bradenburg, Maklenburg-Vorpommern, Thüringen. With the higher average life expectancy Eastern regions can increase the demand for housing. [Zensus, 2011b]

Western regions are more attractive for migrants as they possess better economic development level, wider career opportunities, higher social benefits. [Zensus, 2011c] Demand there is high, not only because of qualified middle-class workers, but migrants who are willing to get a social housing as well. Usually, a part of their families is not going to work at all, so their maintenance is just a burden for the regional economy. Eastern regions are not yet able to supply everyone with high social benefits, so these regions are not often a goal of migrants.

After the reunion of Germany in 1990 the tendency of inner migration was from East to West, that is obvious because of economic and social disparities. The first years after the outflow was the greatest, then it remained the same for the years and slightly came to natural migration rates for average regions. Afterwards, the trend changed and part of the population, especially young, preferred to move to Eastern regions for new career opportunities, high-quality education of Berlin and Dresden and lower housing prices and living costs. However, this shift can be mostly explained by the effect of Berlin, the key city of destination for inner migrants. Its value in migration was so high, that the statistics show that East nowadays is attractive for move to than West [Federal Institute for Population Research (BiB), 2021]. In former GDR many mass-houses were constructed, that is not correspond to nowadays comfort and aesthetic standards, so its price does not rise by the years and price for rent is quite low [Listov, 2016].

The supply side of the housing market differs depending on regions. Overall construction activity rises for approximately 3% with a tendency for many-family houses, while detached houses lost 1,5% of their popularity [JLL, 2019]. In Western regions the disproportion of housing supply structure between rural and urban areas is significant. For instance, in Dusseldorf the population density is high, and approximately 12% of houses are detached, while in countryside around this rate is higher than 90% [JLL, 2019]. East is leading in new construction tempo higher for nearly 20% than in Western regions by recent years. Almost 1/3 of housing fund of East is pre-WW2 houses, while West inherited only 22% of them. Main part of the German houses is constructed from 1949 to 1978, but the construction was different in its characteristics. In GDR the construction was public and private buildings were not encouraged. In 70s many typical mass buildings were erected and nowadays they still exist, but are renovated to be up-to-date. However, in FRG private construction was supported by governments and people were able to get subsidies and concessional loans, so the housing fund there became more diverse and multitudinous. Nowadays Eastern regions are characterised by new construction and renovation boom. Vacancy rate is not homogenous too. It shows the rate of housing

that is not used for its initial purpose, like not yet sold ones and ones to be demolished. It is higher is Eastern regions, but the tendency to decrease is obvious. [JLL, 2019]

By now housing polarization shifts from East-West to agglomeration level. People prefer to spend more to get better infrastructure and career opportunities. Germany presents a lot of extended agglomerations of big cities and their suburbs with almost similar, but a bit lower price level. Almost a half of German population lives in agglomerations like Berlin, Cologne, Hamburg, Munich and smaller ones like Freiburg and Dresden [Hennig, 2018]. Average population growth rate is negative, while number of agglomeration dwellers rises.

German federal lands have different Real Estate Transfer Tax rates. It is paid with the fact of property transfer to another owner. It is logically to suppose that this tax would be higher in Western rich regions and Berlin, but it is not so exactly. For instance, in Bayern the tax is the lowest at 3,5% and in Eastern Saarland, Thüringen and Brandenburg it is the highest at 6,5%. Other Eastern lands have quite high 5,0% tax and Berlin – 6,0%. Western regions diverse tax rates from 3,5% to 6,0%. [Günther, 2019] Overall, Eastern lands, surprisingly, have higher property transfer tax rates than Western.

As it was mentioned above, housing prices greatly reflect the economic situation of the region. This mechanism shows that rich regions have higher price level and better infrastructure, for which people are ready to pay and the demand does not drop. So, it is important to analyse housing price in different regions to understand their economic environment and observe some tendencies of regional development over time.

It is interesting to illustrate the prerequisites of disparities in nowadays German regions. After the reunification of 1990 Western and Eastern regions were economically different due to half-century opposite economic environment. In Western länder there were market economy with free trading and private property, while in Eastern was command economy with strict price control.

After the regions united, the control in Eastern part cancelled and prices rocketed. It was a challenge for the population, as the structure of rental and selling market completely changed, even re-formed. Back that time it was rather easier to construct new houses instead of renovation of the existing fund of city centres, so the mass investment and construction started in suburbs [Michelsen, Weiß, 2010]. In 2001 the program Stadtumbau Ost was introduced. Its aim was the demolishment of unneeded fund and its replacement by new infrastructure. Instead of these houses new ones were erected outside the city [Bernt, 2009]. All in all, these actions increased the 'sleeping' housing fund and vacancy rate of the East cities significantly. Mass migration established this tendency further.

After 2009 real estate prices in German metropolitan areas significantly increased. The regional dispersion rose especially after the financial crisis of 2007-2009. Overall, prices in former FRG are higher than in the East, and the only exclusions are Berlin and Baltic region, which have upward price trends [Kauffmann, Nastansky, 2019].

Nowadays the main market tendency is the agglomeration formation. The polarization West-East shifts more to the polarization between clusters. Nowadays half of the population live in main agglomerations such as Berlin, Hamburg, Munich, Dresden and Cologne [Hennig, 2018].

Literature Review

The main contribution of our paper is the analysis of determinants and spatial effects in housing prices, taking into account whether the region belong to high-prices or low-prices clusters using quantile regression analysis. The results of the analysis with and without quantile dimension differ a lot not only in term of statistical significance and coefficient size, but quite often in the signs of its effect. So, the consideration of housing price quantiles can bring new peculiar results for existing determinants analysis and make it more precise and realistic.

The panel dimension of the analysis allows to account for regional heterogeneity, whereas spatial regional dimension catches the interaction of close-

located regions: how shocks in real estate price determinants in neighbouring regions affect the housing prices level and to what extent the shock in one region is expanded to other closely located regions. Finally, spatial quantile regression reveals the differences between high-prices and low-prices regions. Taken together they provide a unique opportunity to analyse the fundamental factors affecting real estate prices from the different perspectives.

There is a lot of literature examining determinants of housing prices across the world, but not all of it consider the price category of the housing. Further some relevant works on quantile regression analysis of housing prices will be adduced.

Some authors examine the inner infrastructural features of the housing as the determinants. Different characteristics of housing can be not priced the same way in a given distribution of real estate prices. The difference in value of housing features for different categories of prices exist [Zietz, Zietz, Sirmans, 2008]. Quantile method allows to account the contribution of the characteristics of housing along the housing prices distribution. The effects of infrastructural determinants are usually alike for different quantiles, while the significance varies [Ebru, Eban, 2011]. Housing prices correlate with determinants nonlinearly, so the quantile approach allows to get more precise results [Kim, Hung, Park, 2015].

Urban green spaces' effect on housing prices can be analysed via two-stage quantile regression. The effect varies depending on the submarket and vegetation index. The number of rooms is more significant for lower-priced houses, while schools and such extra infrastructure as air conditioning is more significant for high-priced housing [Özsoy, Şahin, 2021]. Rental prices deflated by CPI rapidly are sensitive to policy changes. Mostly the reforms reduce rents for expensive and new apartments [Fitzenberger, Fuchs, 2017].

All the above-mentioned papers consider mostly infrastructural inner housing characteristics. Currently we want to estimate the correlation of socio-economic factors as migration, employment variables and income determinants with hosing prices, so let us move on to literature considering such factors.

Magnitude and significance of explanatory variables differ across the quantile. Demographic structure of the region and development factors like GDP and vacancy rate as significant determinants, which correlate with liquidity of rental dwellings [Cajias, Freudenreich, Freudenreich, 2020]. Average income positively correlates with the prices, mostly for deciles 0.3-0.9, as its increase characterises the purchasing power of the population [Tomal, 2019]. Housing prices, age, matrimonial status and income affect migration. The prices for housing correlate with migration positively in long run, and the influence in short run is not significant. In short run the correlation is asymmetric: negative below 0.5 quantile, is not significant from 0.5 to 0.8 and positive in 0.9 [Peng, Tsai, 2019].

By conducting current analysis, we want to fill in the gaps in existing literature. Overwhelming majority of works use not socio-economic determinants, such as demographical and income ones, but infrastructural, like number of rooms and other inner features. We include demand side factors, like employment variables and regional and personal income, migration. The quantile regression method allows us to get more precise results, as prices of different types of housing can be affected by different factors.

Data & Methodology

We provide empirical analysis on the panel data set of 397 German regions (NUTS 3) for the period 2004 – 2019 taking into account their relative geographical location and prices. The data for regional prices and determinants are collected by the firm BulwienGesa AG (RIWIS), data for migration was taken from Regional Statistik Genesis. Kauffmann and Nastansky [Kauffmann, Nastansky, 2007] provide a property data description and the methodology of calculation.

Dependent variables are logarithms of selling and rental price growth rate for an apartment. We use rent of the existing apartment price in euro/m^2 (Wiedervermietung Wohnung) and sale price of existing condominium in euro/m^2 (Wiederverkaufspreis Eigentumswohnung). We consider selling and rental prices separately because of various effects of determinants on them. Rental prices react to

the change in economic situation faster than less flexible selling ones. In the case of rents, we consider the net cold rent, excluding incidental expenses and other benefits. The selling prices of owner-occupied apartments are presented without incidental costs. The calculation of average rents and prices includes those cases that can be assigned to a typical group for the respective segment.

As independent variables, in our analysis we use following determinants:

Table 1.

Dependent and independent variables.

Variable name	**Description**
Dependent variable	
Selling prices	Sale prices of existing condominium in €/m^2
Rental prices	Existing apartment rent prices in €/m^2
Independent variables	
Unemployment rate	Unemployment rate, in %
Pendulum migration rate	Number of pendulum migrants by the place of residence in thousands divided by population
Employment rate	Number of employees in thousands divided by population
Wages	€, in current prices
Gross Regional Income	€, per capita, represents gross regional product
Immigration rate	Number of migrants divided by population size for each region in each year
Emigration rate	

We include lags of independent variables.

The prices of housing are affected by supply and demand factors and their dynamic by the years [Case, Mayer, 1996]. The examples of demand sided factors are interest rates and demographic shifts as they affect the population size, the market structure, due to various preferences of social groups. Supply is mostly defined by existing housing stock and infrastructure, and new construction determinants, like investment environment and law changes. In our paper we mostly use demand factors since they are easier to observe, collect and analyse.

We apply quantile regression method to analyse the data. It helps to get separate effects for low- and high-priced housing. To estimate quantile models we apply the technique described in the paper by Machado & Santos Silva, 2019 [Machado, Santos Silva, 2019]. The basic model quantile model there is following:

$$Q_{ln\,Y}(\tau|X_{it}) = \left(\alpha_i + \delta_i q(\tau)\right) + X_{it}\beta(\tau), \quad (1)$$

where $(\alpha + \delta q(\tau))$ illustrate the quantile-τ fixed effect and $\beta(\tau)$ represents marginal effect of the regressor X on the quantile-τ of Y, so-called regression quantile coefficient. The definition is:

$$\widehat{\beta(\tau)} = \arg min\, \frac{1}{n}\left(\sum_{y_i \geq x_i'b} \tau|y_i - x_i'b| + \sum_{y_i < x_i'b}(1-\tau)|y_i - x_i'b|\right), \quad (2)$$

As a method of estimation, the Method of Moments-Quantile Regression (MM-QR) is used. This approach is weaker in the prospect of robustness, but is appliable to panel data.

In our case the basic model's specification looks like:

$$Q_Y(\tau|X_{it}) = \left(\alpha_i + \delta_i q(\tau)\right) + X_{it}\beta_1(\tau) + Migration_{it}\beta_2(\tau). \quad (3)$$

We include the independent variables if logarithms, excluding migration factors because of some negative values. The independent variables are in logarithms as well, so the final variant of basic quantile model is following:

$$Q_{ln\,Y}(\tau|X_{it}) = \left(\alpha_i + \delta_i q(\tau)\right) + ln\, X_{it}\beta_1(\tau) + Migration_{it}\beta_2(\tau). \quad (4)$$

To broaden the analysis, we include the additional regressors, which represent the determinants multiplied by weighting matrix W. This way we can estimate the effects of neighbouring regions to the prices for housing in the considering ones. The specification is:

$$Q_{ln\,Y}(\tau|X_{it}) = \left(\alpha_i + \delta_i q(\tau)\right) + ln\, X_{it}\beta_1(\tau) + Migration_{it}\beta_2(\tau) + WX_{it}\beta_3(\tau) + WMigration_{it}\beta_4(\tau). \quad (5)$$

W is a n×n spatial weighting matrix. Non-zero elements of the matrix W indicate that the region *j* is a neighbour for the region *i*. Diagonal elements of the matrix are zeros. Matrices are row standardized so that the weights of all neighbouring regions sum up to 1. We employ two specifications of weighting matrices in our analysis: a matrix based on inverse geographical distances between the regional centres (inverse distance matrix) and a matrix based on regional common borders (contiguity matrix). These types of matrices are often used in spatial regional analysis (see e.g. [Burgess, Profit, 2001], [Niebuhr и др., 2009]), since they provide a good approximation for connectivity between regions.

We estimate one more model specification. We build IVQR (Instrument Variables Quantile Regression) to deal with the endogeneity of the independent variables [Chernozhukov, Hansen, 2006]. The instrument variables are weighted determinants ($\ln X_{it}$ $and\ Migration_{it}$, $WX_{it}\ and\ WMigration_{it}$, $W^2X_{it}\ and\ W^2Migration_{it}$).

The specification is following:

$$Q_{\Delta \ln Y}(\tau|\Delta X_{it}) = \alpha_0 + \rho W\, \Delta \ln Y + \Delta \ln X_{it}\beta_1(\tau) + \Delta Migration_{it}\beta_2(\tau), \quad (6)$$

where α_0 is constant, $\rho W \ln Y$ is the spatial lag of logarithm of housing prices. To get fixed effects estimations, we include all the variables in the following form: $\Delta\theta = \theta - \bar{\theta}$, where $\bar{\theta}$ is the average value of variable (*within)* by years.

Results and Interpretation

Firstly, we analyze the results for basic quantile model (4). In the table 2 the results for selling prices are shown. The model shows how socio-economic factors affect the prices of selling and rent in the considered regions.

Postestimation opportunities after quantile regressions are very limited. We have tested the models and found out, that there is multicollinearity in data. The residuals are not normally distributed. Autocorrelation and heteroskedasticity are not a problem for model estimation for our methodology [Machado, Santos Silva, 2013]. Moreover, the estimation does not include R^2 value or any other measure of goodness of fit, as it is not representable in the case of quantile analysis [Stata List].

Table 2.

Results for selling prices quantile regression

*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	0.1 sell	0.2 sell	0.3 sell	0.4 sell	0.5 sell	0.6 sell	0.7 sell	0.8 sell	0.9 sell
Unemployment	-0.147***	-0.158***	-0.168***	-0.179***	-0.191***	-0.207***	-0.225***	-0.244***	-0.268***
	(0.0162)	(0.0139)	(0.0123)	(0.0110)	(0.0104)	(0.0114)	(0.0142)	(0.0182)	(0.0240)
Pendulum migration by the place of residence	8.52e-07**	8.68e-07***	8.82e-07***	8.98e-07***	9.17e-07***	9.40e-07***	9.66e-07***	9.93e-07**	1.03e-06*
	(3.65e-07)	(3.14e-07)	(2.77e-07)	(2.47e-07)	(2.33e-07)	(2.55e-07)	(3.18e-07)	(4.08e-07)	(5.40e-07)
Wages	0.0678***	0.0663***	0.0650***	0.0635***	0.0617***	0.0595***	0.0571***	0.0545***	0.0512***
	(0.0131)	(0.0113)	(0.00993)	(0.00885)	(0.00837)	(0.00914)	(0.0114)	(0.0146)	(0.0194)
GRI	0.528***	0.518***	0.510***	0.500***	0.489***	0.475***	0.459***	0.442***	0.421***
	(0.0462)	(0.0397)	(0.0350)	(0.0312)	(0.0296)	(0.0323)	(0.0402)	(0.0517)	(0.0684)
Immigration	1.669**	1.909***	2.116***	2.349***	2.621***	2.966***	3.351***	3.755***	4.271***
	(0.650)	(0.559)	(0.493)	(0.440)	(0.417)	(0.455)	(0.567)	(0.728)	(0.962)
Emigration	1.014***	1.028***	1.040***	1.053***	1.069***	1.089***	1.111***	1.135***	1.165***
	(0.229)	(0.197)	(0.173)	(0.154)	(0.146)	(0.159)	(0.199)	(0.255)	(0.338)
Observations	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352

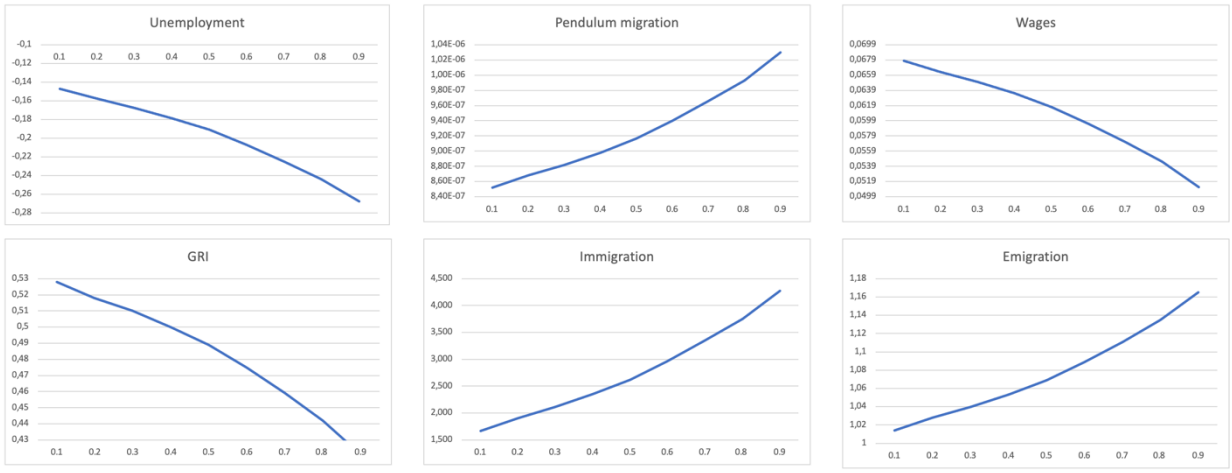

Figure 1. Statistically significant coefficient for selling prices for quantile regression. Coefficient values on the vertical axes, quantiles on the horizontal axes.

We observe that socio-economic factors affect the selling prices of housing with the same direction, but heterogeneously in term of power. Unemployment has negative effect on selling prices, and it increases by the quantiles. More expensive housing is more sensitive to unemployment. This correlation is quite natural as

unemployment make population uncertain about future and current income and they tend to lower the demand, especially on luxury housing. The existing literature usually consider the negative effect of unemployment on housing prices in quantile analysis [Kartal, Depren, Depren, 2021].

Pendulum migration is positively correlated with the selling prices, and the effect rises for the quantiles. It is so due to the effect of agglomeration and allocation. Commuting of population higher the prices along with the increase of overall economic conditions of the agglomeration. Aggregate demand for housing rises and so do the prices for housing. There are very few researches of correlation between commuting and housing prices across quantiles, the authors usually consider the location of commuting hubs instead of number of pendulum migrants. Overall, the negative effect of travel distance on prices is concluded [H.Bohman, Nilsson, 2016], but our determinant has a different nature.

Wages have positive effect on selling prices. The power decreases by the quantile. Positive effect can be observed because of increase of the demand, especially for selling. The decrease of the effect is quite curious, but can be explained by the scale effect. More expensive housing is less sensitive to income changes. The positive correlation conforms with the existing literature [Tomal, 2019].

Gross Regional Income positively correlate with the price of selling, mostly for lower quantiles. Overall economic development increases the price level of the region. Most sensitive are lower quantiles, as an increment in economic level significantly raises the demand for such housing, while the demand for more expensive is not that flexible. Positive correlation and its increase by the quantiles was previously described in literature [Zhu, Li, Guo, 2018].

Immigration and emigration both have positive effect on selling prices, that is quite unusual. The effect of immigration is significantly higher and can be explained by the extra demand by new population. Positive correlation between migration and housing prices is usually described in literature [Peng, Tsai, 2019]. The positive effect of the emigration is not easy to explain, as outflow of the population decreases the demand and so the price. Both effects rise by the quantile.

Table 3.

Results for rental prices quantile regression

*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	0.1 rent	0.2 rent	0.3 rent	0.4 rent	0.5 rent	0.6 rent	0.7 rent	0.8 rent	0.9 rent
Unemployment	-0.148***	-0.154***	-0.158***	-0.163***	-0.167***	-0.173***	-0.180***	-0.188***	-0.198***
	(0.00916)	(0.00755)	(0.00656)	(0.00591)	(0.00573)	(0.00631)	(0.00772)	(0.00995)	(0.0134)
Pendulum migration by the place of residence	4.20e-07**	4.19e-07***	4.19e-07***	4.19e-07***	4.18e-07***	4.18e-07***	4.18e-07***	4.17e-07**	4.16e-07
	(1.80e-07)	(1.49e-07)	(1.29e-07)	(1.16e-07)	(1.12e-07)	(1.24e-07)	(1.52e-07)	(1.96e-07)	(2.64e-07)
Wages	0.0434***	0.0405***	0.0383***	0.0360***	0.0336***	0.0306***	0.0272***	0.0234***	0.0181*
	(0.00648)	(0.00535)	(0.00464)	(0.00418)	(0.00405)	(0.00446)	(0.00547)	(0.00704)	(0.00951)
GRI	0.311***	0.305***	0.300***	0.296***	0.291***	0.284***	0.277***	0.269***	0.258***
	(0.0252)	(0.0208)	(0.0181)	(0.0163)	(0.0158)	(0.0174)	(0.0213)	(0.0274)	(0.0370)
Immigration	1.059**	1.336***	1.551***	1.765***	1.993***	2.286***	2.604***	2.972***	3.474***
	(0.480)	(0.396)	(0.344)	(0.311)	(0.301)	(0.332)	(0.406)	(0.523)	(0.705)
Emigration	0.538***	0.528***	0.520***	0.513***	0.505***	0.494***	0.483***	0.470***	0.452**
	(0.139)	(0.115)	(0.0996)	(0.0898)	(0.0869)	(0.0957)	(0.117)	(0.151)	(0.204)
Observations	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352

Figure 2. Statistically significant coefficient graphs for rental prices for quantile regression. Coefficient values on the vertical axes, quantiles on the horizontal axes.

The results for rental prices are very much alike. The differences are the power of the effects of pendulum migration and emigration across the quantiles. Pendulum migration has positive effect on housing prices with the reducing power by the quantiles. Rents of expensive housing are less sensitive to the commuting. It may be explained by the fact, that the regions with higher housing rents are more economically developed and so attractive for commuters. They already have high demand and prices, to react more gradual to new commuters. So, the effect of increase of pendulum migration is less, than for regions with smaller prices.

Emigration positively correlates with the rental prices; the effect is less than for selling and falls by the quantiles. Low-priced housing increases in value much more, than high-priced ones.

The following results are describing the effects of socio-economic shifts in neighbouring regions on the selling and rental prices in the considered ones. Interestingly, the effects for considered regions, included to the models, are not significant, so we present the effects only of neighbouring ones.

Table 4.

Results for rental prices quantile regression (neighbouring regions)

VARIABLES	0.1 rent	0.2 rent	0.3 rent	0.4 rent	0.5 rent	0.6 rent	0.7 rent	0.8 rent	0.9 rent
W*Unemployment	0.00550	0.00843	0.0107	0.0132	0.0159	0.0185	0.0210	0.0234	0.0262
	(0.0643)	(0.0530)	(0.0448)	(0.0360)	(0.0285)	(0.0243)	(0.0245)	(0.0287)	(0.0367)
W*Pendulum migration	1.30e-06	3.16e-06	4.57e-06	6.22e-06*	7.92e-06***	9.57e-06***	1.12e-05***	1.27e-05***	1.45e-05***
	(5.91e-06)	(4.87e-06)	(4.12e-06)	(3.31e-06)	(2.62e-06)	(2.23e-06)	(2.26e-06)	(2.64e-06)	(3.37e-06)
W*Number of employees	0.515*	0.407	0.325	0.229	0.130	0.0335	-0.0595	-0.148	-0.252
	(0.306)	(0.252)	(0.213)	(0.171)	(0.136)	(0.116)	(0.117)	(0.137)	(0.175)
W*Wages	0.136*	0.163**	0.184***	0.208***	0.232***	0.257***	0.280***	0.302***	0.328***
	(0.0771)	(0.0636)	(0.0537)	(0.0432)	(0.0342)	(0.0292)	(0.0295)	(0.0345)	(0.0440)
W*GRI	0.496***	0.513***	0.526***	0.541***	0.557***	0.572***	0.587***	0.601***	0.617***
	(0.190)	(0.156)	(0.132)	(0.106)	(0.0840)	(0.0715)	(0.0723)	(0.0846)	(0.108)
W*Emigration	0.134	0.474	0.733	1.035***	1.347***	1.650***	1.943***	2.221***	2.548***
	(0.712)	(0.587)	(0.497)	(0.400)	(0.317)	(0.270)	(0.273)	(0.319)	(0.407)
W*Immigration	0.707	0.795	0.861	0.939*	1.019**	1.097***	1.172***	1.243***	1.327**
	(1.001)	(0.825)	(0.698)	(0.560)	(0.444)	(0.378)	(0.382)	(0.447)	(0.571)
Observations	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955

*** p<0.01, ** p<0.05, * p<0.1

Figure 3. Statistically significant coefficient graphs for rental prices for quantile regression (neighbouring regions). Coefficient values on the vertical axes, quantiles on the horizontal axes.

Wages in neighbouring regions positively correlate with rental prices in considered regions. It can be explained by the allocation effect. The effect is higher for regions with expensive housing. More economically developed regions are more attractive, so the increase in wage inspire people to rent more, so the demand rises.

Pendulum migration in neighbouring regions has positive effect on rental prices in the considered ones. The effect is significant starting from quantile 0.4 and rises up to 0.9. The correlation can be explained by the increasing demand for rent in the regions by commuters.

Gross Regional Income in neighbouring regions is positively correlated with rental prices in the considered regions. Income increase improve the economic situation in the region and stimulates the agglomeration effect, so the prices rise not only in the region, but around it too due to the ripple effect.

Immigration and emigration both have positive effect on rental prices. Emigration leads to demand increase in considered region, and so the prices rise. The positive effect of immigration can be explained by allocation.

All the effects rise by quantiles, so high-priced region rental prices are more sensitive to the changes in demographic and income factors.

Results for selling prices quantile regression (neighbouring regions) Table 5.

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
VARIABLES	**sell**	**sell**	**sell**	**sell**	**sell**	**sell**	**sell**	**sell**	**sell**
W*Unemployment	0.204	0.216	0.225	0.234	0.247**	0.259**	0.269**	0.278**	0.288*
	(0.248)	(0.205)	(0.174)	(0.145)	(0.116)	(0.105)	(0.112)	(0.130)	(0.159)
W*Pendulum migration	1.88e-05	2.35e-05	2.70e-05	3.07e-05**	3.55e-05***	4.04e-05***	4.41e-05***	4.76e-05***	5.18e-05***
	(2.51e-05)	(2.07e-05)	(1.76e-05)	(1.46e-05)	(1.17e-05)	(1.06e-05)	(1.13e-05)	(1.31e-05)	(1.61e-05)
W*Number of employees	0.877	0.638	0.458	0.264	0.0154	-0.235	-0.427	-0.606	-0.819
	(1.149)	(0.949)	(0.808)	(0.671)	(0.537)	(0.485)	(0.520)	(0.601)	(0.737)
W*Wages	0.223	0.299	0.357*	0.418**	0.497***	0.577***	0.638***	0.695***	0.763***
	(0.307)	(0.254)	(0.216)	(0.180)	(0.144)	(0.130)	(0.139)	(0.161)	(0.197)
W*GRI	0.807	0.836	0.857*	0.881**	0.910***	0.941***	0.964***	0.985***	1.011**
	(0.717)	(0.592)	(0.504)	(0.419)	(0.335)	(0.302)	(0.324)	(0.375)	(0.460)
W*Emigration	0.792	1.553	2.126	2.742*	3.531***	4.327***	4.936***	5.507***	6.184***
	(2.831)	(2.339)	(1.992)	(1.655)	(1.325)	(1.197)	(1.280)	(1.481)	(1.817)
W*Immigration	0.667	1.049	1.337	1.646	2.042	2.441	2.747	3.034	3.373
	(3.802)	(3.142)	(2.674)	(2.221)	(1.776)	(1.605)	(1.718)	(1.988)	(2.440)
Observations	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955

*** p<0.01, ** p<0.05, * p<0.1

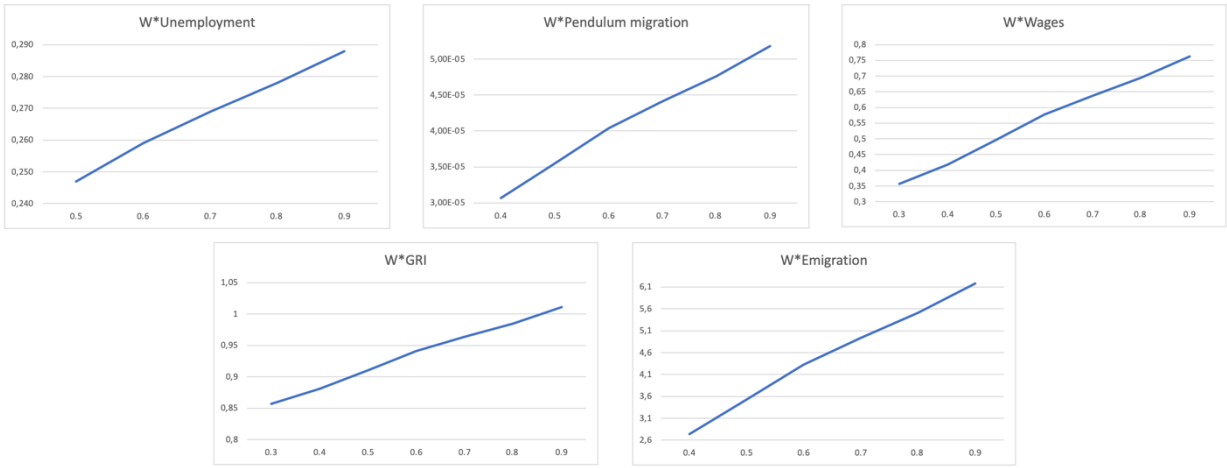

Figure 4. Statistically significant coefficient graphs for selling prices for quantile regression (neighbouring regions). Coefficient values on the vertical axes, quantiles on the horizontal axes.

The correlations of factors and prices for selling are overall alike. Immigration effect is not significant, while the effect of unemployment is. Its increase in neighbouring regions leads to the rise of selling price. It can be explained by the demand flow to other regions. Extra demand in considered regions increases the prices for selling. The effect is higher for high-priced regions.

The final specification is IVQR. We add spatial lags of dependent variables to estimate the spatial effects across the quantiles. Instrument variables (weighted determinants) help to deal with occurring endogeneity.

Table 6.

Results for selling prices IVQR

VARIABLES	0.1 sell	0.2 sell	0.3 sell	0.4 sell	0.5 sell	0.6 sell	0.7 sell	0.8 sell	0.9 sell
ρ	2.280***	2.103***	1.977***	1.866***	1.770***	1.674***	1.563***	1.435***	1.218***
	(0.0575)	(0.0513)	(0.0492)	(0.0492)	(0.0506)	(0.0532)	(0.0575)	(0.0637)	(0.0772)
Unemployment	-0.0284**	-0.0383***	-0.0453***	-0.0515***	-0.0569***	-0.0622***	-0.0684***	-0.0755***	-0.0877***
	(0.0114)	(0.00978)	(0.00910)	(0.00887)	(0.00899)	(0.00938)	(0.0101)	(0.0113)	(0.0139)
Wages	0.0412***	0.0439***	0.0457***	0.0474***	0.0488***	0.0502***	0.0519***	0.0538***	0.0570***
	(0.00622)	(0.00530)	(0.00503)	(0.00510)	(0.00540)	(0.00586)	(0.00659)	(0.00757)	(0.00951)
GRI	0.0921***	0.0997***	0.105***	0.110***	0.114***	0.118***	0.123***	0.128***	0.138***
	(0.0348)	(0.0296)	(0.0268)	(0.0253)	(0.0248)	(0.0251)	(0.0264)	(0.0290)	(0.0354)
Immigration	4.717***	5.113***	5.392***	5.639***	5.853***	6.065***	6.313***	6.597***	7.080***
	(0.206)	(0.197)	(0.211)	(0.235)	(0.263)	(0.295)	(0.337)	(0.387)	(0.479)
Emigration	0.276	0.418***	0.518***	0.606***	0.682***	0.758***	0.847***	0.948***	1.121***
	(0.185)	(0.162)	(0.162)	(0.175)	(0.193)	(0.217)	(0.249)	(0.290)	(0.365)
Constant	-0.268***	-0.177***	-0.112***	-0.0556***	-0.00604*	0.0429***	0.100***	0.166***	0.277***
	(0.00636)	(0.00499)	(0.00392)	(0.00345)	(0.00310)	(0.00345)	(0.00425)	(0.00517)	(0.00875)
Observations	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352

*** p<0.01, ** p<0.05, * p<0.1

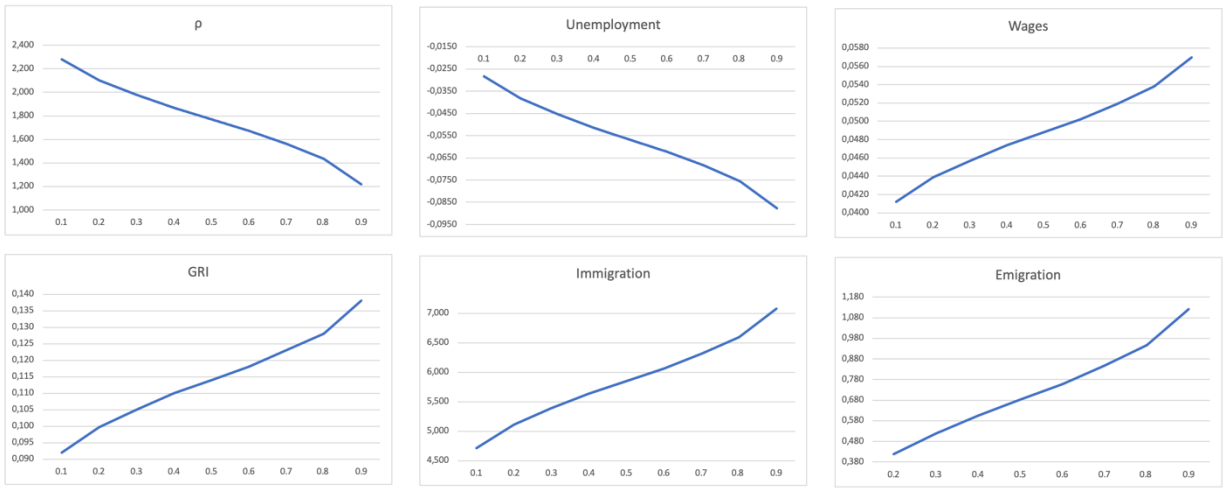

Figure 5. Statistically significant coefficient graphs for selling prices IVQR. Coefficient values on the vertical axes, quantiles on the horizontal axes.

The results show the decrease of spatial effects by the quantiles. Low-priced regions are more affected by the location, than high-priced ones. Unemployment has negative effect on selling prices, the effect is higher for upper quantiles.

The effect of other factors rises by the quantiles. Wages, GRI, immigration and emigration are positively correlated with the price. The possible mechanisms of the effects were discussed before.

Table 7.

Results for rental prices IVQR

VARIABLES	0.1 rent	0.2 rent	0.3 rent	0.4 rent	0.5 rent	0.6 rent	0.7 rent	0.8 rent	0.9 rent
ρ	2.113***	1.997***	1.918***	1.851***	1.788***	1.717***	1.635***	1.539***	1.398***
	(0.0659)	(0.0579)	(0.0551)	(0.0548)	(0.0562)	(0.0598)	(0.0659)	(0.0751)	(0.0913)
Unemployment	0.0369***	0.0298***	0.0249***	0.0207***	0.0168***	0.0124**	0.00732	0.00137	-0.00739
	(0.00581)	(0.00505)	(0.00478)	(0.00474)	(0.00486)	(0.00517)	(0.00573)	(0.00656)	(0.00804)
Wages	0.0202***	0.0268***	0.0312***	0.0350***	0.0386***	0.0426***	0.0472***	0.0526***	0.0606***
	(0.00370)	(0.00310)	(0.00287)	(0.00283)	(0.00293)	(0.00318)	(0.00361)	(0.00425)	(0.00535)
GRI	-0.0464**	-0.0185	0.000466	0.0167	0.0318**	0.0487***	0.0685***	0.0916***	0.126***
	(0.0217)	(0.0187)	(0.0171)	(0.0161)	(0.0157)	(0.0157)	(0.0164)	(0.0181)	(0.0218)
Immigration	3.197***	3.823***	4.249***	4.613***	4.951***	5.332***	5.777***	6.295***	7.057***
	(0.146)	(0.131)	(0.129)	(0.133)	(0.142)	(0.156)	(0.175)	(0.203)	(0.247)
Emigration	0.0773	0.0670	0.0600	0.0540	0.0485	0.0422	0.0349	0.0264	0.0139
	(0.107)	(0.0927)	(0.0867)	(0.0845)	(0.0850)	(0.0884)	(0.0959)	(0.108)	(0.131)
Constant	-0.167***	-0.112***	-0.0751***	-0.0433***	-0.0138***	0.0195***	0.0583***	0.104***	0.170***
	(0.00388)	(0.00287)	(0.00231)	(0.00202)	(0.00195)	(0.00247)	(0.00285)	(0.00354)	(0.00476)
Observations	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352	6,352

*** p<0.01, ** p<0.05, * p<0.1

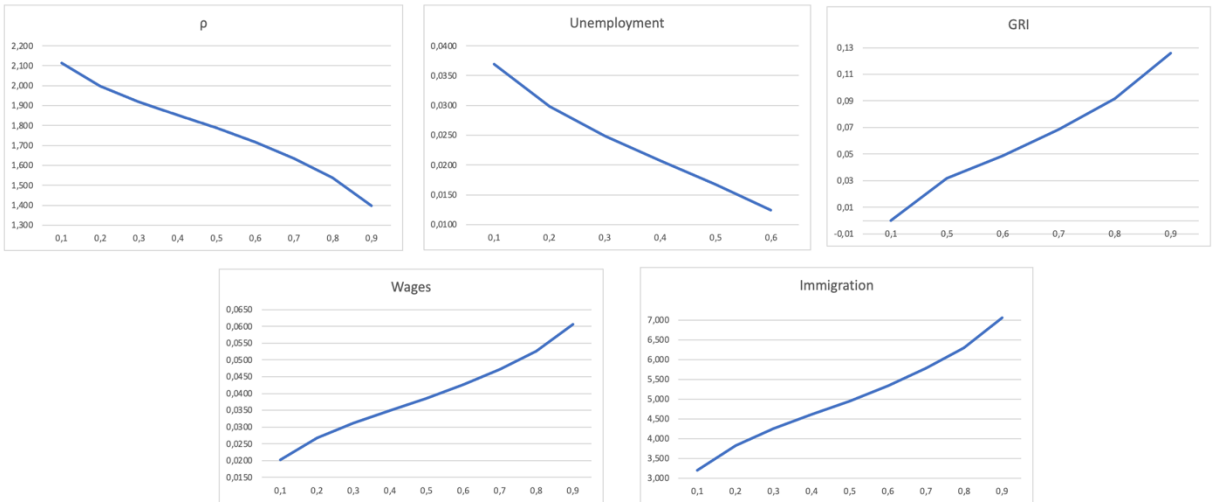

Figure 6. Statistically significant coefficient graphs for rental prices IVQR. Coefficient values on the vertical axes, quantiles on the horizontal axes.

The results for rental prices IVQR are very much alike, but emigration is not significant in this case.

All in all, the considered models provide a complete view on selling and rental prices of regions and their neighbours. The effects are heterogenous, but their directions do not fluctuate across the quantiles.

Conclusion

Quantile regression method provides a more precise illustration of correlations between socio-economic factors and housing prices. We observe not just an aggregate effect, but can conclude for which price types of regions correlation is higher.

Spatial allocation of regions plays an important role in real estate pricing: regions located close to regional centres benefit from it, which is easily accounted by spatial correlation. We found a high spatial effects for regions; they rise by the quantiles, so the relative positive spatial dependence is higher between regions with high housing prices and lower for less attractive regions.

We also find spatial effects for the determinants: a demand change in a region affects the price also in the neighbouring regions. The effects of neighbouring regions are usually explained by the flow of demand or agglomeration effect.

The results of the analysis suggest that the demand-side factors increase the housing prices in most cases. From the spatial quantile regression analysis, we estimated that regions with higher prices are more sensitive to infrastructural or policy changes, whereas low prices regions experience more sluggish reaction. Migration variables positively correlate with the prices for housing.

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